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"WAR MINERALS" AS A SCIENCE.

C. K. LEITH.

The war has not developed new minerals nor changed the character of old ones, and yet we find ourselves using the new and euphonious term "war minerals," indicating that something new has come into the mineral field. We understand the general import of the new term, and yet have difficulty in precisely defining it. Perhaps to-day's definitions will not fit the situation of to-morrow. The term implies that a mineral is essential to the conduct of the war or that problems of supply have been raised by war conditions, such as restriction of shipping. It may imply only shortage, and not its vital necessity for war purposes.

One cannot go far into the subject before discovering that "war minerals" present problems not only of geology, but of metallurgy, transportation, trade, finance, diplomacy, and even military strategy. In fact the new term covers a constantly widening and ill-defined field, bristling with problems for both peace and war, which must be approached from many angles by specialists in many professions. To illustrate: The ship shortage requires a large diminution of manganese imports to the United States. Manganese ore becomes a "war mineral." It is necessary to study and develop domestic supplies; to use lower grade domestic ores; to modify iron and steel practice; to introduce important changes in specifications for the alloys; to make neces-

sary price and trade adjustments; to secure the necessary co-operation of the trade; to consider the domestic development with reference to both war and post-war conditions; to consider the needs of allies, neutrals, and enemies; to study the world distribution and routing to determine what part manganese will play in the future in relation to world compacts, commercial and diplomatic; to determine what degree of internationalization of this important resource may be necessary or desirable.

The economic geologist finds himself pitched into a new and largely uncharted field requiring study of new conditions and use of new methods of study. He is asked specifically, may importation be stopped completely or in some degree and the ore supplied from local sources? If so, what sources, what amounts, and what grades? May this be done immediately? Do the domestic grades require different methods of extraction or use? To what extent are the changes in the industry permanent, and to what extent are they temporary war expedients? What shall be the governmental relation to the temporary measures? What changes in distribution or transportation will this involve? What are our obligations to allies and neutrals? What part does manganese play in the program of our enemies? In short, how may the manganese industry in its larger sense be modified to meet the present crisis? To answer these questions intelligently there must be an interpretation of the underlying philosophy of the dependence of civilization on this resource.

Economic geologists under the stress of circumstances are attempting to answer these questions, but the answers are yet entirely inadequate. The barest beginnings have been made. Clearly no geologist is qualified to answer all of these questions. In fact, the best directed efforts of the profession as a whole will not answer them, for many phases of the problems can be satisfactorily investigated only by the economist, metallurgist, chemist, statesman, financier, and soldier. The problem is too large for any single science, and the field of each science will require extension. Even if the enlarged circles of the several professions overlap, this will at least diminish the intervening dark spaces in the problem. Unless all concerned with minerals project their

thought outside the traditional fields of investigation, vital war questions will not be adequately answered. We shall have missed a great opportunity to make the full weight of our science felt in solving the present world problem.

In this coöperative field I like to think that the knowledge and training of the geologist peculiarly fit him to take up some of these new problems and aid materially in their solution. He is called upon to extend his science to points of contact with other sciences—to interpret his science more broadly for the benefit of others. The fact that he passes beyond the traditional limits of his field does not mean he is entering a non-scientific field, for scientific method in the new field is vital. He is laying the foundation for a new science—possibly one that will require a new name. Now we refer to it simply as "war minerals," but it is clear that some of the new conceptions relating to war minerals apply also to considerations of "peace minerals." This enlargement of horizon does not mean abandonment of old fields of investigation, but should result in a broader and saner grasp of the problems of geology by bringing them into a clearer perspective.

Geologists are attempting to solve war-mineral problems in connection with many public agencies. Mr. Spurr, in another article, briefly refers to certain of these problems developed in study of shipping conditions. Mr. Bastin, on other pages of this magazine, gives some account of the government agencies. Outside of these agencies throughout the country there is much geologic talent awaiting the call to service. The difficult problem at present is to find some way to use this talent and get it focused on war problems. The best that can be done under the circumstances is for each geologist to inform himself as far as possible on the work already under way, to get in touch with the various existing agencies, and to use his own initiative in taking up some of the many phases not yet adequately covered.

WAR MINERALS.

J. E. Spurr.

The interest of economic geologists and mining engineers in these days is centered on the problem as to how they can be of maximum service to the country in this time of the nation's supreme effort. The application of geology to military affairs has been considerably debated and we believe that a study on this subject would constitute an interesting contribution to the pages of this journal. All forms of engineering are of great immediate importance in military operations, as has been recognized by the formation of separate engineering units in the army, including that of the mining engineers. The work which the mining engineers perform in the army is, however, one that often has little to do with applied geology.

Leaving out of the question the debatable problem as to the degree of practicability of the application of geology to military campaigning, it is clear that the mining geologist and the practitioner of the other forms of applied geology has a great usefulness in bringing about greater efficiency in the affairs of the nation in the department in which he is proficient. In time of war the affairs of life and of the nation are constantly separated into essentials and non-essentials and articles of production into necessities and luxuries, and any essential business which deals with necessities becomes a war industry and the application of economic geology to any of these becomes an application of economic geology to military affairs. Since the nation is essentially an armed camp and the necessary industries are as actually a part of the campaigning and can no more be dispensed with than can the supply and hospital units be dispensed with in the army in the field, it therefore results that where a mining geologist or mining engineer is engaged in such a way that he is increasing the production of a necessary metal he is virtually doing more effective

military work than if he were in uniform. He is a trained officer in the great industrial army which forms the reserve and the supply organization for the field army, and which provides for this advance army, arms, munitions and other necessities.

During peace times, when commerce is uninterrupted, the relative importance of certain metals within the United States is not a question which assumes great importance in our eyes, for what we do not have at home we can get abroad and sometimes more cheaply. But when our sources of supply in certain countries from which we are accustomed to draw are shut off by our being at war with them and where other sources of supply are restricted on account of the scarcity of shipping requiring curtailment of imports, it begins to be understood what vital strength there is in having great metallic resources within our boundaries and how great an importance lies in their being discovered, classified and developed. We have gone a certain distance in this work of adjustment but we can go very much further if necessary. It is in this adjustment work that the services of economic geologists can be of great value. The work of the writer has brought him within close touch with these problems and it is thought that a very brief synopsis of the situation, in regard to our principal war minerals (meaning by this term those minerals in regard to which the war brings up new problems of supply), would be of interest and would perhaps serve some good end. In the following paragraphs, therefore, minerals will be taken up alphabetically and a few words of description offered as to the war problems involved. These notes cover a few of the principal features of a study of war minerals undertaken for the United States Shipping Board in coöperation with C. K. Leith.

Antimony.—The United States is depending upon oversea imports for antimony, which is used in making shrapnel bullets. Should a satisfactory substitute for antimony be developed for hardening lead it may be possible to reduce these imports. Domestic deposits, so far as known, are limited.

Arsenic.—The United States imports arsenic principally for use as an insecticide. There is no scarcity of arsenical ores in the United States, but the arsenic in these ores has hitherto

mostly been blown up the smelter stacks and wasted. It is understood that this will be corrected in the future. No particular geological problem is offered here, but the question is one of smelter practice.

Asbestos.—Although the United States has very little asbestos its good neighbor Canada has abundance for all purposes. It would be of interest, however, if a workable deposit of the so-called blue asbestos or crocidolite could be found either in the United States or Canada. The demand for this is small but imperative and this variety is now imported from South Africa.

Bauxite and Aluminum.—There are large deposits in Georgia, Alabama, Arkansas and Tennessee, and the United States has always supplied its own material. The aluminum industry, however, has had an immense growth and it is looking forward to securing a supply more and more in the future from outside sources, since the American resources will apparently not be sufficient. Further discoveries of bauxite would be of great interest. The demonstration of the practicability of manufacturing aluminum from other materials than bauxite would be revolutionary in the industry.

Bismuth.—Very little bismuth is used in this country and most of it is derived from the United States. This is a war mineral of no great importance.

Chalk.—We import great quantities of chalk from England. It is essential in many of its uses including the manufacture of whiting, as a filler in the manufacture of rubber goods, as a base for cold-water paints, in the manufacture of putty, in the glazing of porcelain and pottery, for moulds in brass foundries and for insulating purposes. We have in this country no material known to the trade in general which is equal to the imported article, and although importation of this material is conducted with very little loss of ship efficiency on account of its coming over as ballast in regular liners, it would still be a national asset to discover and catalogue a domestic material which would be a satisfactory substitute. The present substitute consists of domestic whiting manufactured from limestone and as a by-product in the manufacture of magnesium carbonate and this substitute, owing to the

crystalline character, is not as desirable or as effective as chalk whiting.

Chromite.—Chromite is one of the most essential of war minerals on account of its use in hardening steel. It is an ore which is irregularly distributed and usually occurs in ore deposits of irregular form. The sources of the world's supply have fluctuated. Until the early part of the nineteenth century the world's supply came from Maryland and Pennsylvania until an American discovered chromite in Turkey. Thereafter for a long time the Grecian Archipelago supplied the world. More recently, with the increased demand for chromite due to the war, the principal sources have been in Rhodesia and in New Caledonia, both remote from the United States. Within the United States new fields have been discovered in California and Oregon, and in Canada in Quebec, and from these we have drawn part of our supply. Very recently, on account of the war emergency, chromite has been discovered, developed and to a certain extent mined in Brazil, Cuba and Central America.

The stimulation of the production of chromite in North America is one of the most patriotic services in which a mining geologist can engage. Certain economies are possible in the use of this ore and some of these have recently been brought about by government pressure. Still others can be brought about by further, more detailed and patient work on the part of the government. Economy in the use of materials containing chrome and in the use of chrome in the manufactures is a patriotic duty not in any way second to the saving of wheat. Steel companies have already arranged, as a result of government suggestion, to economize in the use of chromite in steel manufacturing. It is expected that economies in the use of chrome in the tanning of leather will be adopted as rapidly as possible. It is understood that the development of chromite fields in Cuba will be undertaken at once, which will take some of the burden off shipping required to bring ore from Brazil and New Caledonia. The developments already made in this direction have made possible the program of limiting, for the present, further importations from New Caledonia; a program which has been acquiesced in by

the various government departments and by the steel and chemical industries. The stimulation of the production of the Cuban deposits would be as much a patriotic service as that of the domestic or Canadian deposits. Similarly there are chromite fields in Newfoundland and the stimulation of the production of these fields so far as feasible would be of great value.

Clay.—One of the most important of our war minerals is clay of the finer variety which is imported in large quantities for use in making china, porcelain, paper filler, paper coating, tiles, sanitary ware, oil cloth, etc. The importation comes from England in special cargoes and domestic manufacturers of these commodities have been unable, hitherto, to use more than a certain proportion of domestic clay mixed with the imported article. It is, therefore, necessary to continue importation.

There is a wide scope of usefulness for the economic geologist and technologist in this field of clays. He may engage in work on problems leading towards the greater utilization of domestic clay instead of the imported article for various uses which have hereto been depending upon the latter. Like all our other industries these clay-using industries are largely empirical and will not change their ancient formulas upon which they have built up a successful business unless under some strong pressure or shock, although this condition is being ameliorated by modern ceramic technology. Before the war a certain clay which came from Germany was held to be absolutely indispensable in the manufacture of graphite crucibles, but since the war the production of graphite crucibles using domestic clay as bond material has continued without serious interruption.

Correspondence with the users of imported English clay for the industries above specified elicits the fact that in certain cases a way has been found to utilize domestic material, although in other instances the substitution would be more difficult, as in the case of electric porcelain. Tiles and sanitary porcelain represent a field where some manufacturers use the domestic and some the imported article, and the latter cling very closely to their methods.

Another service, and one for which geologists are fitted, is the location and bringing to notice of deposits of clays in other parts

of the country than those in which the present mines are situated. All domestic clay of the higher class comes at present chiefly from Florida, Georgia and South Carolina and the problem of transportation of the large tonnage of this material to the northern points where it is utilized is almost as great a one, involving the tax on the railroads that it does, as is the shipping of the imported article. The use of clay as a paper filler, for example, is one which absorbs the larger portion of the imported clay and moreover the paper mills are situated at some distance from the domestic deposits. New finds of clay suitable as paper filler in the northern states near the paper factories would be of great value, or the location of other deposits which could be used as a paper filler, such as talc.

Copper.—Copper is a war mineral of which we have a scant sufficiency and any mining geologist who is engaged in copper mines is probably doing as much for his country as he can do anywhere. We are moreover obliged to import copper metal and matte from some distance by water as, for example, from Chile and Japan, and the larger the production of domestic copper, the less necessary would be these oversea imports with the attendant use of shipping needed for trans-Atlantic purposes.

Cryolite.—Although cryolite is a war mineral, it is not very important, and it is perhaps hardly proper to mention it in this particular, as it does not occur except in Greenland. Nevertheless we are obliged to mport a small quantity of this mineral for use in the manufacture of aluminum, but its place will soon be entirely taken by the artificial cryolite which is now being manufactured in larger quantity than the amounts of the natural ore which are imported.

Flint-Grinding Pebbles.—We have no satisfactory domestic substitute, so far as known, for the flint-grinding pebbles which we import from Denmark and from France. These are used in cement works, in metal mines and for grinding feldspar and silica for making chinaware, for grinding colors, etc. We have certain deposits of domestic pebbles which have been used for less delicate purposes, such as in the milling of ores and in cement works. Nearly all these pebbles contain impurities, especially iron, which

makes their use impossible in uses like that of grinding silica and feldspar for the pottery trade and making electric porcelain, and grinding materials used in making lenses and chemicals. Most of the metal mines can get along without the imported pebbles if necessary and the cement mills could, like the mines, mostly substitute steel balls; but, with the present scarcity of steel, this is hardly a desirable substitute, from the war mineral standpoint.

Voluntary economy and employment of substitutes for imported flint pebbles for grinding purposes on the part of mining geologists and mining engineers would, again to quote our former language, be a saving equal in patriotic value to the saving of wheat, provided the substitutes come from some nearby region and reduce the strain upon our transportation facilities by sea or land. Geologists should bring deposits of pebbles which seem to be of value in this respect to the attention of users in their neighborhood, for the purpose of experiment.

Fuller's Earth.—Most of the fuller's earth used in the United States is a domestic product, but in 1917 we imported something over 15,000 tons from England. The imported fuller's earth is used exclusively in bleaching of edible oils including olive oil, cottonseed oil and lard. Eighty per cent. of the fuller's earth produced in the United States comes from Florida and is used in filtering lubricating oils. Deposits of fuller's earth suitable for bleaching purposes occur in Texas and Georgia and have been used as a substitute for the imported article. Some of the largest manufacturers of edible oils use domestic and some insist upon the necessity of the imported material. Deposits of fuller's earth should be investigated. Wherever a source of domestic supply can be used which will reduce the transportation necessary for the imported article or for the domestic earth found in the south, a great help will be made toward the industrial efficiency of the country.

Graphite.—We have considerable deposits of domestic graphite, principally in Alabama. The flake, however, is a small one and not esteemed very highly by domestic manufacturers of graphite crucibles, which are used in the manufacture of crucible steel. Nevertheless, tests show that satisfactory crucibles can be

made from it. Domestic crucible makers prefer the graphite from Ceylon, but the British and French manufacturers use that which comes from Madagascar. The importation of Ceylon graphite has been restricted and if close attention is paid to the preparation of domestic graphite for the market it should in time overcome the prejudice of the crucible manufacturers and become a substitute for the imported article. In the past these prejudices have been very well founded on account of lack of care, in numerous cases, on the part of the producers. Domestic graphite is largely used for other purposes than crucibles and will be used almost exclusively for this purpose until the end of the war.

Iron Ore.—Any mining geologist engaged in any part of the great work of producing iron ore can scarcely be in a more serviceable occupation.

Magnesite.—Before the war the United States consumed about 300,000 tons of magnesite annually, of which about 290,000 tons were imported. Of the imported material, that suitable for refractory purposes was imported from Austria-Hungary, and a pure fine grade of magnesite imported from Greece was used for plastic purposes such as flooring. With the cutting off of former supplies, magnesite deposits were fortunately discovered and developed in California and Washington. California produced 250,000 tons of magnesite in 1917 similar to that formerly imported from Greece, and Washington produced about 100,000 tons of the crystalline variety suitable for refractory purposes in 1917. It is estimated that these deposits can double their output in 1918. Due to these new industries it has become possible entirely to dispense with the importation of magnesite. This is an essential war mineral, especially as it is being used to take the place of chromite as a refractory and is an essential part of the economic program entered into by the steel corporations, in consequence of government representations.

Manganese.—No war mineral has a greater importance than manganese on account of its use in steel manufacturing, hardening steel for war, and other essential purposes.

With the cutting off of manganese from Russia by the war and the subsequent shortage of imports of manganese from

India on account of decreased shipping, the bulk of the high-grade ore has been lately drawn from Brazil. We have not in this country sufficient high-grade ores to make high-grade ferro-alloys from ferromanganese. Nevertheless, the present stringency in shipping has made it necessary to reduce the importations of manganese to the lowest possible point and the steel manufacturers, under government advice, have entered into a campaign of economy involving a maximum use of domestic ores such as are fitted for the lower-grade alloy called spiegeleisen. The maximum production of domestic manganese of all grades is one of the most urgent things in the war, especially as difficulties of labor and transportation threaten this as well as other essential industries which run up into large tonnages. No greater service could be rendered by mining geologists than to assist in any way in the production of domestic manganese ore, or by metallurgists than in devising and practicing increased economies and a larger use of the low-grade alloy in the steel manufacture. In this matter nearly every section of the country has its interests and possibilities.

Mercury.—The United States produces its own requirements of mercury and has some left over to ship our Allies. This is an important war mineral and domestic production should be maintained. Mining geologists should keep this in mind and do what they can to increase the production when the matter is brought before them.

Mica.—Mica is an essential war mineral on account of its use in making electrical apparatus. We import a higher grade of mica for this purpose, largely from India, although we have some high-grade mica in this country which is used for electrical purposes, for example, some of that which comes from New Hampshire in the vicinity of Keene. The Indian mica is valued by the trade on account of its pliability and the fact that it is standardized better than the domestic article. A certain amount of mica has also come in from Brazil on account of the supply from India being difficult to obtain.

Deposits of sheet mica should be carefully examined and tested to see whether it is satisfactory for the more exacting uses and

can be produced commercially. The increase of a supply of our domestic mica of higher grade would relieve us of the necessity of importation, although the tonnage is a small one.

Monazite.—Monazite is used in the manufacture of thorium, which is used in making incandescent mantles for gas burners. These are considered a war necessity, as specially demonstrated in England, where the manufacture of toluol from illuminating gas has greatly reduced the illuminating power and necessitated the employment of these mantles. A by-product of the thorium manufacture is mesothorium, used in the manufacture of luminous paints and in other ways as a substitute for radium.

We import nearly all our monazite from India and Brazil. Deposits of monazite sands occur in North Carolina and Florida but cannot compete commercially with the imported article and are very much lower grade. Labor conditions are very bad in the domestic monazite districts and no considerable amount of monazite could be produced at present except at an enormous price. All things considered, it seems best to regard our domestic monazite as a low-grade article which we may use in case of emergency, when it would be very valuable, and to conclude to husband our resources in this respect.

Nitrates.—Our importation of nitrates from Chile are enormous. Although most of the material imported is used for the manufacture of explosives, a large quantity is used for agricultural purposes as a fertilizer. Most of the wheat and corn of the country are grown without the use of fertilizers and the same is true of more than half of the cotton crop. But other crops, such as the truck gardens and potato farms of the east and about half of the cotton plantations of the south, depend upon artificial stimulation of the soil. It is true that the continued growing of crops in the west without fertilizers cannot go on indefinitely and more and more a system of crop rotation or a more extended use of fertilizers will be required. At the present time, however, it is imperative that a minimum amount of nitrogen compounds necessary for explosives should be used for agricultural purposes.

There are large stores of organic nitrogen in cottonseed cake and meal, tankage, blood, fish scrap, etc., of domestic origin that

can be advantageously mixed with acid phosphate rock. There is a growing opinion that the necessity and advantage of the great use of sodium nitrate and ammonia sulphate as fertilizer may have been overrated and that the necessary nitrogen can and should be found more in organic ingredients and that the permanent solution of the agricultural nitrogen problem may be found in the soil bacteria rather than in electro-chemistry.

It is most essential that in every way possible economy in the use of sodium nitrate and ammonia sulphate should be practiced and it would be a patriotic service for the farmers to do everything possible to minimize the use at the present time of inorganic nitrogen.

Platinum.—Platinum occurs in this country, but not in quantities sufficient to supply our demands, which have been met from Russia and to a smaller degree from Colombia. Platinum occurs in the United States in certain ores, as in Wyoming and California, and to a small extent in sands, as those of the Columbia River, and as a by-product in refining metals. Wherever possible the production of platinum should be increased. Platinum jewelry should not be purchased and any amount of platinum which may be held privately, no matter how small, should be turned over to the government.

Pyrite.—Pyrite, which with sulphur is used in the manufacture of sulphuric acid, is a very important war mineral. We have up to recently imported large amounts of pyrite from Spain. This importation has been cut down to a fraction of the usual amount and an effort is being made to produce sufficient domestic pyrite to make up the deficiency, together with the use of sulphur from the southern deposits in Louisiana and Texas. Those engaged in the production of pyrite should make every effort to see that this production is maintained and increased to the greatest possible extent, because upon this production will depend the feasibility of maintaining the present restriction of imports with its attendant ship saving, so vital in the present emergency.

Tin.—Tin in North America, as is well known, is sparse and of low grade and has yet to be of any commercial importance. Our demands for tin as a war mineral are very large. It is an

essential, as it goes into the making of food containers which supply our army. The price of tin has increased very greatly on account of the demand for it and it is possible that in the near future conditions might be such that some of our domestic deposits might contribute something towards the general supply. The tin of the Seward Peninsula in Alaska appears to be the most promising locality. Any production which can be made from this or other regions will be of great help in the war program.

Tungsten.—Tungsten, which is used as a hardener of steel, is a war mineral of importance, and although deposits of this ore are scattered throughout the United States yet we do not produce sufficient for our own consumption and import something like 5,000 tons a year from other countries, principally from South America. The country is vitally interested in a larger production of tungsten ore in the United States which would remove the necessity of using shipping for importing it. Wherever geologists and mining engineers can assist in the production of tungsten they should regard it as a patriotic service.

Vanadium.—The above remarks on the subject of tungsten apply principally to vanadium also. We have domestic supplies of vanadium, but not enough is produced to satisfy our needs for the use of this material for war purposes as a hardener of steel; therefore we are obliged to import this ore from Peru to the extent of about 3,500 tons a year. Those owning vanadium prospects or able to engage in producing the ore should consider it a matter of duty to produce all that they can, because the shipping which brings this ore from the west coast of South America is barely sufficient for bringing in other commodities, such as nitrate, which we do not produce at all in this country.

We have gone over separately the different war minerals above mentioned and sketched very briefly their necessity for the reason that geologists and mining engineers are scattered all over the continent and anyone of them may, on occasion, find opportunity for increasing the production or even of finding new localities for some of these important materials and be enabled thereby to add his bit to the work which is going on for the common good.

PETROLEUM IN JAPAN.

J. Morgan Clements.[1]

HISTORICAL.

For a number of years petroleum has ranked among the highest, third, in value, of the mineral products of Japan. The petroleum industry is really one of the relatively old industries of the country, although it is only since 1891 that it has been put upon a modern basis. A picture is extant showing the presentation in 668 to the Emperor Tenchi (Tenji) of "burning water" and "burning earth," by his subjects from Echigo Province. The "moyuru-mizu," burning water, was doubtless oil, and the burning earth was probably bituminous shale, or other oil-soaked rocks coming from near the seepages of oil. The early methods of getting the oil were very simple. Where the seepages occurred, as at Kurokawe in the Niitsu field in Echigo, a trench along the seepage, or shallow wells were dug and allowed to fill with oil, which was then bailed out. In some cases they filled with oil and water and overflowed. It is reported[2] that about 1818 the oil men began to sink deeper wells dug by hand. Some of these deeper wells must have been dug, it would seem, long before this time, for the oil was utilized to a limited extent in Echigo, where it was first discovered, during the 300 odd years preceding the Moiji Era, 1868. Its potential value was not recognized until kerosene began to be imported and used in Japan. Then when the Japanese learned early in the Meiji Era that kerosene was derived from the natural oil, with which they were acquainted, they began to develop their natural resources by digging deeper wells by hand to obtain more oil, and also by refining the oil by crude methods to produce illuminating oils.

[1] Article published with permission of the Bureau of Foreign and Domestic Commerce.

[2] "Mining in Japan," page 25.

In the refining they were guided by information obtained from the books available to them. Later on still deeper wells were dug by hand to reach the oil sands. The deepest one of these, of which I could learn, reached a depth of 894 feet.

In 1876 Benjamin Smith Lyman, an American who had been studying the mineral resources of Hokkaido for the Japanese government, was sent into the Echigo oil district and prepared geological maps of the oil fields. These were the first which had been made and were, of course, of great assistance. Based on them, the Japanese oil producers began more enlightened development of the fields, but still keeping to the hand dug wells. Toward the end of the "eighties" an American well-drilling outfit was secured, but the repeated efforts to drill a well to the oil sands failed, as the result of the lack of experience of the Japanese operators of the drill. The Nippon Petroleum Company, incorporated in 1888, with Mr. Hishahiro Naito the president then, as he is now, secured a complete well-drilling outfit and a competent drill man through the Japanese Consul in New York, and in the fall of 1890 the drill was set up over an old dug well. Drilling was started in December of the same year, and a well 1,000 feet deep was completed in April, 1892, and began with a production of 45 barrels per days of oil of 42° Baumé. Other productive wells were drilled in succession to a depth of 1,500 feet. This successful use of American drilling outfits led to the rapid adoption of them by the progressive Japanese. Drill outfits and drillers to operate them were brought to the Japanese oil fields. Going even farther than this, as the industry developed, the Nigata Iron Works, owned then by one of the large oil companies, sent its superintendent, Mr. Sasamura, to the United States to study the manufacturing end of oil drilling and refining machinery and supplies. On his return a company entered upon the manufacture of these essentials to the oil industry, and today produces a large amount of the necessary oil-drilling machinery and supplies, following closely the American prototypes. At the present time most of the equipment for drilling wells and refining oil is produced in Japan. Casing is,

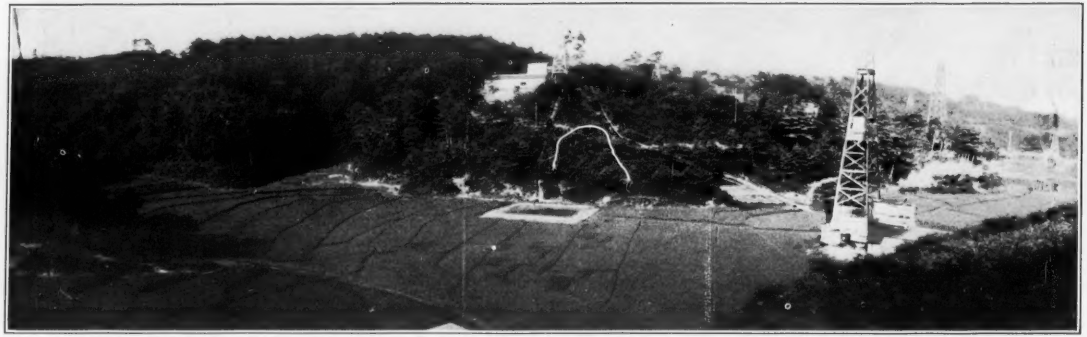
however, still bought in the United States. The derricks used are of the usual American type. A view of a Japanese oil field immediately strikes one on account of its close resemblance to the American fields, and it is only later that one notices the differences in the surrounding trees, and types of agriculture and laborers one sees around the wells.

It has been the well-established policy of one of the large oil companies to send some one abroad from time to time to study the oil industry in other parts of the world. When it has been decided to introduce any innovation whatever, the new outfit required is purchased and brought to Japan with an experienced foreign man to run it until the Japanese employees have been trained to handle the machines and operate them. In 1912 American rotary drills were introduced with American drillers, and are now widely used and the Japanese operate them. The same is true in refining. An American trained in a Standard Oil Refinery in the United States is now aiding in the operation of at least one important refinery.

The first gusher was struck with American drill tools on the coast at Amaze in the Nishiyama field, Echigo District in 1891. This naturally gave great impetus to the oil industry. It is interesting to note that while the large oil companies use extensively American rotary and cable tool drills, there are also used, however, alongside them, the Japanese bamboo spring poles and bamboo string rigs, and one may also see alongside the modern wells and modern types of well-drilling machinery, the "Tebori," deep wells dug by hand.

The Nippen Oil Company, Ltd., and the Hoden Oil Company, which operate wells, pipe lines and refineries, practically control the oil industry of Japan, as they buy most of the oil produced by others. The Standard Oil interests were for a while represented by the International Oil Company, but they sold out some years ago, in the summer of 1907, to the Nippon Oil Company, and now the Standard Oil Company operates in Japan only as a seller of petroleum products.

General View of the Nishiyama Oil Field.



Details Showing Tank Below Oil Well to Prevent Waste Oil from Getting into Irrigation Channels.

OIL DISTRICTS.

There are five oil districts in Japan proper, situated in the provinces of Echigo, Shinano, Akita, Totomi, Hokkaido, and one in Taiwan (Formosa). In each of these districts there are one or more fields in which oil is found to occur. In addition to the productive fields, there are others which have been tested and have been proven to produce such small quantities that they could not be operated successfully at this time. Some new fields will doubtless be discovered in the future in these oil districts. Echigo, Akita, Totomi, Hokkaido and Taiwan districts all produce oil today. Of a total daily production of 15,848,[3] 42-gallon barrels of oil, as reported, Totomi, Hokkaido and Formosa only produces 113 barrels, or less than 1 per cent. of the total. Echigo and Akita are the two large oil producing districts, producing 99 per cent. of all the Japanese oil.

The oil fields of Taiwan are in process of development at the present time. The Japanese Navy Department holds five fields which have been reserved for it by the government, but these fields have not yet been thoroughly tested. The Aiko is generally said to be the most promising of these, and will probably be tested first.

Echigo District is the largest of the oil districts; included in it are a number of fields, each of which is small, and only four of which, the Nishiyama, Higashiyama, Nittsu and Kubiki are now producing an appreciable quantity of oil. In addition, the Omo and Uonuma are small producers. New producing fields are likely to be brought in in the Echigo district by further developments in depth, and also through the discovery of oil-producing areas under the broad plains of the valley.

GEOLOGY.

The oil in Japan is associated in all cases with the Tertiary deposits, though every Tertiary area of Japan is not found to carry oil. The oil fields are found in the areas of Tertiary sediments

[3] Figure obtained from a large oil company. This does not check with annual production.

distributed along the seacoast, excepting in Hokkaido, where the oil district of the Ishikari Valley is near the center of the island. A probable oil field has been reported also in Saghalien.

As has been stated, the Echigo and Akita districts produce 99 per cent. of all of the oil of Japan, and I chall briefly describe only these two districts. They both occur in the extensive area of Tertiary sediments which occur almost continuously along the West coast of Honshu, the main island of Japan, bordering the Japan Sea, extending from Shinano Province on the South to the northern end of the island. These Tertiary oil-bearing areas are broken up into a series of small mountain ridges, the highest rising to an altitude of 2,300 feet, although the general height is much lower. Between the ridges occur broad fertile plains covered with rice fields and traversed by meandering streams, used largely for irrigation.

The ridges normally correspond to the anticline and have the same strike northeast to southwest, while the valleys occupy the synclines. Broadly speaking the oil fields correspond with these anticlines. It is probable that in the future new oil fields may be developed in some of these broad plains between the ridges, but as there are no structural guides occurring in the plains it may be some time before the oil operators will venture to drill them.

The Tertiary has not been closely subdivided in Japan but is probably represented by both Miocene and Pliocene deposits. In the Echigo[4] and Akita districts there are three defined oil horizons. The upper one consists of shale, sandstone and conglomerate, and the middle one of shale, with thin beds of sandstone. The lower horizon is subdivided into two parts, an upper one of sandstone and shale and a lower one of shale, sandstone and tuff beds. The most productive oil strata are in the middle and lower horizons. The sandstone and tuff are the chief oil carriers, though some oil is obtained in places from the shale. Volcanic rocks, lavas, tuffs and dikes are found in the Tertiary with the oil strata, sometimes contemporaneous with and some-

[4] "Preliminary Note on the Geology of Echigo Oil Field," T. Iki, Memoirs of the Geological Survey of Japan, No. 2. pp. 29–57, Tokyo, 1910.

times intrusive in the sediments. Wherever the oil strata are cut by an intrusion the oil is reported to be of low specific gravity,[5] often averaging even less than 10° Baumé. It is noticeable also that the heavy oils occur in the highest horizons as a rule.

The Nishiyama field is the most productive one in the Echigo District and is typical. The axis of the Nishiyama anticline strikes N45°E., and the northwest side of the anticline has dropped down along a fault along the axis. The shallow wells occur on the southeast side of the anticline. Those so far developed range in depth from 1,490 feet to 1,790 feet. On the northwest side of the anticline occur the deeper wells. The average depth along here is 2,980 feet. The deepest one so far drilled is No. 73, which reached a depth of 4,613 feet.

Both cable and rotary drills are used in drilling these wells. The beds are relatively soft. With the cable drills the average progress is 20 to 35 feet per day. The record is 60 feet. With rotary drills the average advance is from 100 to 125 feet per day, and the record is 500 feet.

A number of flowing wells have been brought in. The largest gusher of which I learned was brought in May 25, 1914, in the Kurokawa lease in the Akita district, and flowed 10,000 koku,[7] equivalent to 11,350 barrels of 42 gallons per day. The flow rapidly decreased in quantity and after about five months it was necessary to pump. A small gusher was reported to have come in in the Akita district with a flow of 1,362, 42-gallon barrels. The production from the oil wells throughout Japan is small. Even the small wells may flow for a short time, but must soon be pumped. The average daily production for the Nishiyama field, the most productive one in Japan is only 4 koku per well, equivalent to 4.5 42-gallon barrels, and the average for the entire Echigo oil district is only 2 koku per well, equivalent to 2.25 42-gallon barrels per day.

[5] "Preliminary Note on the Geology of Echigo Oil Field," T. Iki, Memoirs of the Geological Survey of Japan No. 2, p. 56, Tokyo, 1910.

[7] 1 koku = 1.135 barrels of 42 gallons.

GAS.

The only field in which gas is produced in quantity is the Nishiyama field in the Echigo district. At the present time one company produces from this field 4 million cubic feet of gas per day. Casing head gasoline is extracted from this and the gas is distributed through a six-inch pipe line, five miles long, to be used as fuel in the houses, under boilers and in gas engines.

CHARACTER OF THE OIL.

The oil varies somewhat in the different fields in the same district, and in the different sands of the same field. As a rule, the higher grade oils occur in the lower horizons. Generally speaking, the Japanese oils are heavy oils. A fair average for them is 30° Baumé. The highest grade oil is from the small Tōtōmi district, which averages 42° Baumé; and the heaviest from the Akita district, which averages 20° Baumé. Beginning in Hokkaido, northern Japan, and going south the gravity of the oil in the different districts, according to the published reports, is given in the following list:[8]

Province.	Oil Field.	Degrees in Baumé.	Average.
Hokkaido	Ishikari	37° plus	40°
	Zufutsu	22° plus	
Ugo	Akita	12°–30°	20°
Echigo	Higashiyama		30°
	shallow beds	20°–32°	
	deep beds	38°	
	Nishiyama		36°
	1st bed	23°–72° (sic)	
	2d bed	30°–36°	
	3d bed	35 plus	
	Niitsu	13°–20°	18°
	Kubiki	40°–45°	41°
Totomi	Sagara		43°
	1st bed		
	2d bed		
Formosa	Byōritsu	37°–40°	38.5

The latest record of the depths of producing wells dated back to 1913, is as follows:

[8] "Mining in Japan," p. 139.

DEPTHS OF WELLS.

District.	Oil Field.	American Type Cable or Rotary Drills.	Japanese Bamboo Spring Poles.	Hand-dug Wells.
Echigo	Higashiyama	342′–2442′		300′–540′
	Nishiyama	390′–3300′[9]	426′–708′	468′–804′
	Niitsu	180′–1182′	180′–840′	336′–492′
	Kubiki	336′–2178′		384′–660′
	Oziya	294′–1260′		
Akita		294′–1140′[10]		
Shizuoka (Totomi)	Sagara	1080′–1380′		
Hokkaido	Ishikari	1002′		
Taiwan (Formosa)		312′–810′		480′–720′

OPERATING STATISTICS.

Number of Wells.—At the end of 1912 there were 2,740 producing wells in Japan, of which 2,153 were drilled with American type machines; 301 were drilled with Japanese spring poles; and 286 were dug by hand. At this time 206 wells were being developed; 106 with American rigs; 76 with Japanese spring poles; and 24 were being dug by hand. Since the date of the above record, deeper wells have been dug further out on the slopes of the anticlines, and are proportionately more numerous than formerly in the active fields. In March, 1917, there were 2,840 producing wells in the Echigo district alone. Of these, 2,236 were drilled with American type drills; 318 with Japanese bamboo spring poles, and 286 were dug by hand. The total production for March in this district of Echigo was 158,733 barrels of 42 gallons.

Refineries.—Excepting for a small percentage which is held by the government for the use of the Navy, all of the Japanese oil is refined, as it is too scarce and too valuable to use crude as fuel. The refineries are located in the oil district, and most of them are partly served with pipe lines. In all of Japan there are 300 miles of pipe lines. This total length is made up of relatively short lines leading from the wells to the tanks at the railroad, or to the refinery. The maximum length of any line is 23 miles, from Nishiyama to Naoetsu. A great deal of the oil is hauled to the refineries in tank cars of American type.

[9] The deepest well in this field in 1917 reached 4,613 feet.

[10] This field produced from 1,863 feet depth in 1916.

The refineries follow the American practice closely. The products are gasoline, kerosene, neutral oil (distillate) lubricants, lubricating oils, cup grease, etc., paraffine wax, and residuum. The tar residuum is used generally as a binder for semi-anthracite and coke briquettes, used by the Navy, and for paving purposes. I have also seen it used in a few cases as fuel in the refineries.

Prices.—It is generally estimated that the cost of production of Japanese petroleum averages 50[11] sen per koku.[12]

The following are the official price schedules for crude oil from 1912 to 1917 in yen per koku.

Year.	Standard Light (Higashiyama).	Heavy (Niitsu).
1912	6.90	4.28
1913	8.15	5.65
1914	5.92	3.78
1915	5.39	3.31
1916	7.25	6.18
1917[13]	10.00	12.20

It will be noted that the *heavy* crude oil is quoted higher in 1917 than *light* Nigashiyama oil. This is due to the fact that the heavy oil contains a higher percentage of lubricating oils, which are much needed in Japan at this time. The following are the prevailing market prices for oil products early in September, 1917, in yen.

Gasoline	Y 9.50 in 10-gallon cans.
Kerosene	Y 5.50 in 10-gallon cans.
Neutral oil	Y 4.70 in 10-gallon cans.
Lubricating oils	Y 9 in 10-gallon cans.
Paraffine	Y 25 sen per pound.
Residuum	Y 5.50 per koku.[14]

The oil market of Japan has been passing through considerable changes in recent times. The importation of illuminating oil was made in past years on a large scale, but in recent years has

[11] Y 1 equals 100 sen equals $0.498 cents U. S. at normal exchange; equivalent to about 52 cents at present rate of exchange.

[12] 1 koku equals 1.135 barrels of 42 gallons U. S.

[13] Actual price for September, 1917; others are annual averages.

[14] 1 koku equals 1.135 barrels of 42 gallons U. S.

been to a considerable extent supplanted by the home production. Also the gas and electric industries have been rapidly growing and their use has reduced the demand for kerosene. There has been, however, a greatly increased demand for light oils, to be used in power plants and for automobiles, and for lubricating oils. The demand for the latter has particularly increased as a result of the expansion of existing, and increased number of new, industrial plants which have been constructed. At the same time there has been a reduction in the importation of these light oils and lubricating oils on account of the demand for these products in the United States and in Europe. In fact, it is reported that inquiries in Japan have been received as to the possibility of exportation of these products to the Occidental countries. Prices have shown a steady increase.

Costs.—The average drilling cost of a 3,000 foot well in the Nishiyama district with a rotary drill is Y 5,000 to Y 6,000, including fuel, wages and supplies, but exclusive of casing. Of this total cost the derrick costs about Y 2,000. The average cost for the various Japanese oil districts of a hole 2,400 feet deep, with cable rigs is Y 8,000, with rotary Y 4,000. A well dug by hand to a maximum depth of 895 feet would cost Y 2,000. In drilling the wells the custom is to begin with 8-inch pipe and end with 6-inch pipe. Sometimes 12-inch casing has been used, and at times it is necessary to end with 4-inch pipe.

PRODUCTION.

In 1915 there were eight companies in Japan reporting a production of over 5,000 koku[15] per year.[16] They reported a total production of 2,932,097 barrels. The production and refining of the petroleum in Japan is practically in the hands of two companies, the Nippen Oil Company, Ltd., and the Hoden Oil Company. They are both producers of and refiners of crude oil. Of the above total amount, the Nippen Oil Company, Ltd., is credited

[15] 1 koku = — 1.135 barrels of 42-gallons, U. S.

[16] Companies producing less than 5,000 koku per year are not reported in the official statistics.

with 1,628,291 barrels, and the Hoden Oil Company with 993,-944 barrels. There were apparently in this year only 309,861 barrels produced by other oil producers, doubtless almost altogether from wells dug by primitive methods. The published records of production date from 1874. In that year Japan is credited with a production of 3,499 barrels. The production slowly increased until in 1880 it had reached 30,651 barrels. Then it began to diminish until it reached a minimum of 7,063 barrels in 1884. In 1891 the annual production had reached 63,618 barrels. The result of the successful application in this year of American well drilling tools made itself felt from then on by a steady and greatly increased growth until by 1901 the production amounted to something over one million barrels. In 1914 production passed the two million barrel mark.

The production for recent years is given in the following table:

PRODUCTION OF PETROLEUM IN JAPAN.

Year.	Barrels of 42-gal ons.	Value.
1912	1,655,159	$4,171,782
1913	1,822,215	6,224,256
1914	2,676,437	4,796,262
1915	2,915,087	4,916,960
1916	2,942,722	7,468,354
1917[17]	2,898,654	

Imports.—Records of the importation of petroleum into Japan date back to 1868, in which year 760.6 barrels were imported. This gradually increased to something over one million barrels by 1893, and 1,949,329 barrels in 1904. Since that time the imports of crude petroleum has decreased, but the imports of petroleum products has increased.

IMPORTS OF CRUDE PETROLEUM AND PETROLEUM PRODUCTS.

	Crude Pertroleum.		Liquid Products.		Quantity, Pounds.	Value.	Total Value.
	Quantity, 42 Gallon Bbls.	Value.	Quantity, Gallons.	Value.			
1914..	59,407	$168,985	37,238,090	$4,657,556	20,026,837	$977,298	$5,803,839
1915..	113,416	355,990	35,436,643	4,430,479	21,603,090	1,081,599	5,868,068
1916..	65,224	204,633	22,977,231	2,928,345	33,297,020	1,915,346	5,048,324

[17] U. S. Geological Suvery.

Practically all of the crude petroleum imported into Japan comes from the United States. The greater percentage of the liquid products also comes from the United States, the next larger amount comes from the Dutch East Indies. For instance, in 1915, there were imported from the United States 27,183,638 gallons, and in 1916, 19,728,305 gallons of kerosene, etc., and in the corresponding years respectively, 7,175,800 and 2,444,427 gallons from the Dutch East Indies.

The solid products, paraffin wax and vaseline, etc., were imported largely from the United States or the Dutch East Indies. and also British India supplied improtant amounts. In 1915 the United States supplied to Japan 7,408,698 pounds of these products, the Dutch East Indies 6,973,565 pounds, and British India 5,090,135 pounds. In 1916, Japan imported from the United States 17,442,425 pounds of solid petroleum products, whereas British India supplied 9,679,321 pounds and the Dutch East Indies 4,525,637 pounds.

Exports.—Under "Mineral Oils" not specified further, Japan reports exports in 1915 valued at $173,832, and in 1916, $3,052,730. Practically all exports go to China, including Ewantung Province.

WAR TIME MINERAL ACTIVITIES IN WASHINGTON.[1]

EDSON S. BASTIN.

RETROSPECT.

In looking back toward the time of our entrance into the war in April, 1917, the feature in connection with the mineral activities in Washington that stands out with especial prominence is the frantic exertion on the part of the newly organized war boards and of the Army to accumulate within the shortest possible time the fundamental mineral information necessary for the intelligent equipping of the nation for war. The necessity for immediate action on many matters relating to mineral industries made it important to secure the necessary data with great promptness and the older bureaus, such as the U. S. Geological Survey, the Bureau of Foreign and Domestic Commerce, and the Bureau of Mines, that had been accumulating mineral information for many years, were besieged by requests and by callers. Requests for much the same information from several of the new organizations or even from different branches of one of them were common, and summary reports presenting in brief the salient features of the situation with respect to various mineral substances were particularly in demand. Many of the demands necessitated new investigations or elaborations of old ones.

At the present time most of the war organizations have been supplied with the fundamental mineral information available, and the new investigations are well in hand. Much more work is being done than a few months ago with less commotion and less duplication of effort, and means have been provided, as will be shown later, to eliminate nearly all unnecessary duplication.

[1] Published by permission of the Director, United States Geological Survey. Mr. Bastin is geologist of the U. S. Geological Survey, and Secretary, Joint Information Board on Minerals and Derivatives.

COLLECTION OF FUNDAMENTAL MINERAL DATA.

The fundamental data upon which the executive officers of the government have had to rely for guidance in mineral matters have been mainly statistical in nature, though supplemented by information derived from field examinations, part of which were special investigations for distinctly war purposes, but most of which had been conducted by the established bureaus long prior to the war. The information required may be classified under the general heads: Available supplies; Domestic and Foreign Reserves; Requirements; Price and cost of production; Uses and consumption. Each of these will be briefly considered:

AVAILABLE SUPPLIES.

Domestic Production.—Prior to the war practically all statistics of domestic mineral production, which were obtained by the U. S. Geological Survey, were upon an annual or semi-annual basis, a frequency adequate in peace times when industries changed only slowly under the operation of the law of supply and demand, but entirely inadequate for war times, when rapid developments and readjustments are taking place in many if not most of the important industries under the stimulus of greatly increased demands, the cutting off of imports to save shipping, and other causes. At the present time the statistics of production for most of the mineral substances of particular importance in the war situation are being obtained monthly, and others, such as copper, lead, zinc and aluminum, weekly, the latter being primarily for the guidance of the government purchasing agents. The Geological Survey is the main agency in the collection of production statistics for mineral substances, though fuel statistics are collected in cooperation with the Fuel Administration and certain derivative materials that are used in explosives such as nitrates and sulphuric acid, are studied statistically by the Chemical Section of the War Industries Board.

Imports.—The statistics of imports of many mineral substances have for a long time been reported monthly by the Bureau of Foreign and Domestic Commerce. Since the outbreak of the

war the publication of these monthly returns has been considerably expedited and certain commodities, such as ferromanganese, formerly reported only quarterly, have also been placed upon a monthly basis. Recently a special arrangement has been made whereby the import statistics for a selected list of mineral commodities are at ten-day periods, the fundamental data being furnished by the customs offices and the compilation being done by the Bureau of Tabulation and Statistics of the War Trade Board.

Exports.—Export statistics have long been compiled monthly by the Bureau of Foreign and Domestic Commerce and for many mineral commodities are now being compiled at ten-day intervals by the Bureau of Tabulation and Statistics of the War Trade Board from shippers' declarations filed with the customs officials.

Stocks.—Prior to the outbreak of the war figures showing stocks of materials on hand had slight utility and very little effort was made to obtain such statistics. In a few cases the stocks in the hands of producers were reported annually. With the interruption of shipping incident to the war and with the later voluntary reduction of imports with a view to saving of tonnage, it has become necessary to know what the stocks of mineral commodities are, not only in the hands of producers but also in the hands of importers, dealers, and consumers. Large stocks for example, might make possible important and immediate reductions of imports not otherwise advisable. The collection of reliable statistics of stocks is difficult but fairly complete data have been gathered with respect to tin, graphite, mica, nitrates and copper, and the collection of statistics for antimony and antimonial lead is now being started. The weekly statistics for copper, lead, zinc, aluminum and antimonial lead include stocks in the hands of producers and commitments, as well as production.

DOMESTIC AND FOREIGN RESERVES.

The increased needs for certain materials and especially the reduction of imports from distant parts of the world has required the collection of much information upon the available reserves

of these minerals in various parts of the United States and in nearby foreign countries, particularly in Canada, Mexico and the West Indies, that might, with little if any utilization of shipping, be made contributory to our domestic supplies. The Geological Survey, the Bureau of Mines, and the Mineral Commodities group of the Shipping Board in particular have been active in the collection of this sort of information. By the first two bureaus a joint field examination of the chromite and manganese resources of Cuba has recently been completed.

REQUIREMENTS.

Requirements also constitute a new line of statistical research of little importance in peace times when the formula consumption = production + imports — exports, based upon annual statistics, furnished a sufficient measure of the country's requirements. The tremendously increased amounts of certain mineral commodities that are now being consumed and the rapid changes that are in progress in their mode of utilization has made necessary special and careful studies of our civil requirements, our military requirements, and the requirements of our allies. In the case of small industries such as the monazite industry, it has been possible to settle the question of requirements for a year in advance at a single conference between the principal consumers and government officials. In the case of chromite, quicksilver, tin and other mineral substances the problem is much more complicated. One difficulty has been the inability of the military authorities themselves to predict their requirements as readily as other requirements could be estimated, because of the changing military situation.

A subsidiary problem in the study of the requirements is the separation of the essential from non-essential and less-essential requirements, which involves the collection of trustworthy data to show the quantities of materials entering into different consumptions. Where the supply of material is limited and non-essential forms of consumption must be forbidden, this class of information assumes considerable national importance. Data on

requirements have been collected by the War Trade Board, War Industries Board, and the Shipping Board, by the Geological Survey and Bureau of Mines, but in the future the War Industries Board will probably be mainly responsible for requirements data. It will have the close coöperation of the Army, Navy and the other organizations mentioned above in gathering these data.

PRICE AND COST OF PRODUCTION.

Price data have been much in demand for the guidance of government purchasing agencies, mainly of the War Industries Board and the War and Navy departments. They have also been necessary to the price-fixing activities of the War Industries Board. Investigations by the Federal Trade Commission to determine the cost of production of certain mineral substances have been a prerequisite to price fixing. Statistical studies now in progress in the Geological Survey to determine the quantities of coal and of copper mined per man in mines with large output as compared with mines of small output may also be of much usefulness in rendering these industries more efficient under war conditions of labor shortage.

USES.

Much attention has been devoted to a consideration of how essential certain mineral substances are in the war economy of the nation as compared with other minerals and with the more important non-mineral resources. These problems are the more difficult because they can not be handled mathematically but at least an approximate solution of them is necessary to the just decision of matters of priority in transportation and in the allocation of both raw and finished products. It is further necessary to have information concerning the most economical form in which certain mineral substances can be shipped as bearing mainly upon the problem of economy in rail and water transportation.

The older bureaus dealing with mineral matters have been able to furnish most of the information demanded except as to mili-

tary uses and have obtained additional data through conferences and correspondence with the industries concerned.

EXECUTIVE USE OF FUNDAMENTAL MINERAL DATA.

With this outline of the nature of the data that have been collected in response to the war time needs, attention may be directed to the uses to which this information has been put by the government departments possessing a greater or lesser degree of executive authority.

THE PURCHASE OR COMMANDEERING OF SUPPLIES FOR GOVERNMENT USE.

The military branches of the government are the only ones which have the power of commandeering, but in the case of the mineral commodities which have recently been commandeered, namely, platinum, palladium and iridium, the War Industries Board has acted as the agent of the Army and Navy and has been charged with practically all the details of the transaction except the actual signature of the commandeering orders. The decision to commandeer and the determination of just how far it was necessary to push this rigorous measure has been based largely upon careful statistical studies by the War Industries Board, the Department of Commerce, and the Geological Survey. The actual purchase of materials for government use devolves upon the departments using the materials, in the present situation mainly the War and Navy departments; but a large share of these purchases are arranged for, or approved by, the War Industries Board, one division of which is charged with the task of correlating the demands of various government departments so that they shall not operate to the detriment of each other or of the industries.

The War Industries Board to meet these responsibilities must keep constantly in touch with conditions in all of the important industries feeding the war machines. To this end the statistics of production, of stocks and of commitments, are now for many

of the more important raw materials reported weekly, generally by telegraph. Copper, lead, zinc, aluminum, antimony and antimonial lead, before the war reported annually or semiannually, are now reported weekly to the Geological Survey primarily for the use of the government's purchasing agents in the War Industries Board. By means of monthly statistics covering the mineral substances and derivatives used in the manufacture of explosives such as sulphur, pyrite, sulphuric and nitric acids, the government purchasing agents are kept in reasonably close touch with these industries also.

REDUCTION OF IMPORTS TO CONSERVE SHIPPING.

To effect the transfer of materials across the Atlantic, we are making more economical use of the ships engaged in trade with our country by the elimination of every ton of imports not absolutely essential in accomplishing our great purpose. Upon the Committee on Mineral Imports and Exports advisory to the Shipping Board, has devolved the task of determining for what mineral commodities imports could be reduced and to what extent. The work of this committee, which has been prosecuted with great energy and judgment, will probably result in the saving of approximately a million tons in cargoes on mineral commodities alone during the year 1918. The task has involved not only the use of all available data concerning present supplies and requirements, but has involved the estimation of mineral resources not yet developed but which could and would be developed to counterbalance the decrease in imports. While resources within our own boundaries are the most important, those of neighboring countries less distant than those from which some of the imported minerals have come have also received consideration. The recommendations of the committee of the Shipping Board are enforced by the War Trade Board through partial or complete embargoes announced in advance or through control of individual import licenses.

REDUCTION OF EXPORTS TO CONSERVE DOMESTIC SUPPLIES, ETC.

To the War Trade Board has been assigned the task of preventing supplies needed by our enemies from reaching them either directly or indirectly, and of reducing or forbidding the export of materials that can not well be spared from our own industries. This control has been exercised through a licensing system, and mineral commodities can now be exported only after a license has been secured.

In fulfilling these functions it has been necessary for the War Trade Board to be informed concerning the uses of mineral substances; the rôle they play in our own economy and the purpose they might serve if they reached the hands of our enemies. It has also been necessary for them to know whether the domestic supplies are sufficient to leave an exportable surplus. The older government bureaus and the War Industries Board have been active in furnishing the War Trade Board with these classes of information; the so-called "Export Conservation List" of this board is constructed on the basis of such information.

Restriction of exports for the primary purpose of saving tonnage has thus far not been largely resorted to, whatever the necessities of the future may demand.

ALLOCATION OF IMPORTS AND OF DOMESTIC PRODUCTION.

In the case of all materials the demand for which considerably exceeds the supply, good policy requires that their use be restricted to those industries for which they are essential. Tin, for example, for supplies of which we are wholly dependent upon foreign deposits, can now be obtained in quantities that are only sufficient if wastefulness is avoided, and under an agreement with the War Industries Board the Pig Tin Committee of the American Iron and Steel Institute has become responsible for the fair and equitable distribution of all supplies with a view of securing the most economical utilizations.

In the case of manganese ore, the importations of which are being restricted in order to save shipping, those supplies of imported ore that are still allowed to come in are of higher grade

than most of the manganese produced in this country and must be looked upon essentially as "sweeteners" to be fairly and equitably distributed where they are most needed, provision being made that such steel manufacturers and others as could successfully use lower grade domestic material should not receive the imported article.

High-grade English clays the import of which requires large ocean tonnages also must be allocated only to those firms producing materials for which the domestic claps are unsuited.

Allocation must be resorted to in the case of certain domestic supplies as well as imported materials. The sulphur supplies of the country must, for example, be allocated only to those acid makers who can not make use of pyrite, of pyrrhotite, or of smelter fumes. Further the allocation of pyrite, of coal and of other mineral commodities should be so controlled as to avoid unnecessarily long or cross hauling in rail transportation.

Allocation of domestic mineral supplies has thus far been limited mainly to the distribution of those needed for government plants and plants working on government contracts. An example is afforded by quicksilver, at least 40 per cent. of the production of which is held subject to government order and distributed under the supervision of the War Industries Board.

ECONOMIES IN CONSUMPTION,—DEVELOPMENT OF SUBSTITUTES, ETC.

Some of the most important recent readjustments in the mineral industry have had for their purpose the avoidance of waste and the development of substitutes in industries using materials of which there was a shortage. The Conservation Division (formerly known as the Commercial Economy Board) of the War Industries Board, whose functions are "to secure economy in the use of men and materials in commercial business to aid in carrying on the war," by obtaining the voluntary coöperation of certain mineral industries has brought about notable economies in consumption and elimination of waste for instance in chrome chemicals, tin and gasoline. In a part of this work they have

had the active coöperation of the Bureau of Standards, which developed babbitt metals and solders containing less than the usual amounts of tin, but apparently are as satisfactory for most purposes as the types richer in tin. Agreements have been reached with the solder and bearing metal manufacturers for large reductions in the tin content of such alloys. This conservation is soon likely to be carried a step farther by the use of lead-cadmium solders. Notable reductions in the tin consumed in so-called tin foils have also been effected.

The Shipping Board jointly with the War Industries Board, has been successful in obtaining the agreement of steel manufacturers to a much larger use of spiegeleisen instead of ferromanganese in the production of steel, thus permitting an increased utilization of domestic low-grade manganese ores and a correspondingly important decrease in the importation of high-grade manganese ores.

STIMULATION OF DOMESTIC PRODUCTION.

With mineral substances, which have an influence on the war program, it has been necessary to use every possible means to increase the domestic production, especially of those mineral commodities whose imports have been restricted, as manganese ore and chromite. Thus far the government has been able to render little direct aid in stimulating domestic production of war minerals, but has helped practically and promptly in indirect ways. It is hoped that legislation now pending will give the government the power to render efficient aid by governmental purchase of war minerals.

Mention should be made at this point of the abandonment by the Bureau of Mines and the Geological Survey of a large share of their investigative work that was not directly connected with war needs and the application of the personnel and the funds so released to the solution of war problems. A large share of the geologic staff of the Geological Survey has been engaged during the past two summers in the examination of deposits of minerals particularly needed at this time, notably petroleum, man-

ganese, chromite, pyrite, sulphur, platinum, and others. The Bureau of Mines has similarly focused a large share of its energies upon the working out of mining and metallurgical problems to stimulate the production or to conserve the utilization of mineral war necessities.

PRIORITY IN RAIL TRANSPORTATION.

It is obviously essential that those commodities necessary in the manufacture of munitions or in other ways very important to the war program, should be promptly transported even at the cost of much delay in the movement of less essential materials. The determination of priority of shipment of mineral commodities rests with the Car Service Section of the United States Railroad Administration, but they have received technical advice upon this matter from organizations possessing detailed information with regard to the part which each of these minerals plays in our industrial economy, particularly from the Geological Survey, the Bureau of Mines, and the War Industries Board. These bureaus have also acted as spokesmen for the mineral industry in transmitting to the Car Service Section, with recommendations, complaints from individual mineral producers regarding their inability to secure cars for the shipment of their products. In transmitting such complaints a statement has usually been included setting forth the importance of the particular mineral concerned. Priorities in rail transportation for coal, coke, and oil are decided by the Fuel Administration with which the Geological Survey is working in close coöperation.

The question of priorities in rail transportation is a most difficult problem involving an estimation not alone of the relative importance of various mineral commodities, but also a weighing of their importance relative to all the other needs of the community and a consideration of such subsidiary matters as the perishability of certain commodities.

FINANCING OF MINERAL ENTERPRISES.

The War Finance Corporation capitalized at $500,000,000, established for the period of the war by an act approved by the

President on April 5, 1918, is empowered to make advances for periods not exceeding five years through banks (or in very exceptional cases, directly) to established and growing businesses whose operation shall be necessary or contributory to the prosecution of the war. It is believed that this act will to some extent stimulate the production of mineral commodities of war importance.

Complementary to the work of the War Finance Corporation are the activities of the Capital Issues Committee of the Federal Reserve Board whose duty it is to pass upon all requests for issuance of securities in excess of $100,000, to determine whether these expenditures are justified under war conditions when unusual demands are being made upon essential industries and when capital must be wisely conserved. The Capital Issues Committee on the one hand prevents the wasteful expenditure of capital and guides it into business operations that are contributory to the war needs and are as economical as possible of labor and transportation facilities. Such worthy operations may in turn receive direct financial aid from the War Finance Corporation. The bureaus possessing detailed information in regard to the mineral resources of the country have been largely called upon by the organizations mentioned above for information concerning the need for increased output in certain mineral industries.

At the present time there is no act under which financial assistance can be given for the development of idle or insufficiently operated mineral properties, but such legislation is now pending, as explained in a later paragraph.

AIDS IN THE DISTRIBUTION OF MINERAL INFORMATION.

As an aid in the distribution of mineral information, to forestall unnecessary duplication of effort, and for the special use of government administrators in obtaining all of the information available upon whatever mineral topic they have under consideration, an informal interdepartmental organization, known as the Joint Information Board of Minerals and Derivatives, was organized in February, 1918, with representatives of thirty-two

government bureaus and boards, a member of the War Industries Board as chairman, and a member of the Geological Survey as secretary. Meetings of this board have been held every week or two weeks for the purpose of focusing on certain topics, which were at the moment requiring administrative action, all the information available in the departments there represented. Thorough discussions were held regarding pyrite, sulphur, and sulphuric acid, manganese, tin and other mineral substances, and from these discussions it is believed that each of the administrative officers present returned to his own special duties with a clearer conception of the broad features of the situation, and with information that would insure harmony between his own activities and those of the other bureaus dealing with somewhat different phases of the same subject. Full minutes of the technical discussions for the confidential use of board members have added to the value of the meetings.

The Research Committee of the National Research Council is also concerned with mineral information as well as most other classes of information, its stated purpose being "the securing, classifying and dissemination of scientific, technical and industrial research information, especially relating to war problems, and the interchange of such information between the Allies in Europe and the United States." The board consists (1) of a civilian member, at present the Director of the Bureau of Standards, (2) the Chief of the Military Intelligence Section of the Army, (3) the Director of Naval Intelligence, and, (4) a technical assistant. The main office is in Washington with branch offices at the American Embassies in Paris and London.

Another organization, the War Minerals Committee, consisting of representatives of the Association of State Geologists, the Bureau of Mines, Geological Survey, American Institute of Mining Engineers, has done important work in disseminating information on mineral matters and in drafting the War Minerals Bill.

The Joint Information Board is entirely an interdepartmental organization but there has been organized in Washington a Service Bureau of the Committee on Public Information for the service of the general public as well as of government officials.

It is its duty to guide inquirers and transmit letters of inquiry as directly and with as little delay as possible to the government departments possessing the information desired, and in the present complexity of the government organization this bureau is proving immensely serviceable.

THE LOOK FORWARD.

The near future appears to hold a promise of greatly increased efficiency and added responsibilities in the federal administration of mineral affairs. The Mineral Administrator Bill, which at the time of the writing has been passed in somewhat different form by both Houses of Congress and is now in Conference, will make possible a larger measure of governmental assistance for the production in our own country of mineral substances of which there is an actual or impending shortage. The exact provisions of this act are still uncertain, but it is probable that it will authorize the government to contract with producers at prices sufficiently high or for periods sufficiently long to materially stimulate production. It will also permit the government to equitably distribute mineral supplies to those to whom they are most necessary for war purposes.

As passed by the House of Representatives the administration of this act is placed with the Interior Department, but whatever government agency enforces the act its task will be an arduous one, calling for the maximum use of all the mineral information at hand, and the technical pesonnel now available in the older departments, particularly the Geological Survey and the Bureau of Mines, and the linking up in some more intimate way of the activities of these organizations with the present mineral activities of the War Industries Board.

DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

ORIGIN OF THE BENDIGO QUARTZ VEINS.

Sir:—The paper by Dr. F. L. Stillwell on "Replacement in the Bendigo Quartz Veins and its Relation to Gold Deposition" in ECONOMIC GEOLOGY, Vol. XIII., pp. 100–111, and the discussion of the paper by Prof. Alan M. Bateman on pages 222–223 of the same volume bring up anew the problem of the origin of those interesting deposits. The "saddle reefs" of the Bendigo Gold-field have made that district famous. This type of ore deposit is also found in Nova Scotia and several other places, but nowhere do the "saddle reefs" seem to be so well developed as in Victoria where they were first recognized. "Saddle reefs" are merely bedded veins which have formed in folded rock strata along the axes of the anticlines. Other types of bedded veins also occur in the Bendigo district, and much of the gold ore has been derived from "spurs"—veins that intersect the beds of sandstone and shale at all angles. These different types of veins are, however, similar in origin, and were evidently formed during a single period of ore formation, for they are everywhere closely related and in places grade into one another.

The "saddle reefs" of Bendigo have usually been attributed to the filling of cavities produced by the arching of the more rigid strata, and some geologists have stated that there is no re-

placement of the country rock by quartz.[1] Dr. Stillwell, in his interesting researches, has now demonstrated that at least some replacement of country rock by quartz has occurred. He does not definitely exclude cavity filling, but strongly emphasizes the part that replacement has played in the formation of the veins. Professor Bateman, in discussing the paper by Stillwell, argues against the exclusive application of the replacement theory, and suggests "that the saddles may represent a combination of both filling and replacement such as takes place in most veins." Neither of these gentlemen refers to the alternative hypothesis adopted by Mr. E. J. Dunn in his beautifully illustrated "Reports on the Bendigo Gold-Field."

In discussing the origin of the "saddle reefs," Dunn states (page 22) that they "have been formed by the deposition of silica from solutions along the axial lines, either in cavities formed by the bending or arching over of beds differing in texture, composition, rigidity, and thickness from one another, . . . or else the saddle reefs filled cavities, more or less occupied by fragments broken off by disruption of the beds along the axes, the quartz filling the interstices first, and then exerting enormous pressure to increase its bulk in a manner common to all substances when crystallizing." In regard to the "leg reefs," which represent the downward extension of the "saddle reefs," he says (page 23): "First the finest film of quartz would be deposited from the solutions that certainly traversed the strata along all the lines of fracture; then these thickened, and wedged open spaces for an extension of the quartz. The solutions of heated water charged with silica were under great pressure, and would consequently penetrate the minutest fissure or crack. Once the silica began to deposit, the crystallizing force would be exerted to widen and enlarge the joints, etc., it occupied, the rift extending as the quartz accumulated."

The views expressed by Dunn are, with certain exceptions, similar to my own, and, since I have recently been making a

[1] Dunn, E. J., "Reports on the Bendigo Gold-Field,' Nos. I. and II., *Special Reports, Victoria Department of Mines*, p. 16, 1896.

Lindgren, Waldemar, "Occurrence of Albite in the Bendigo Veins," ECONOMIC GEOLOGY, Vol. I., p. 164, 1906.

special study of the mechanics of vein formation, it may be of value to summarize here the evidence in favor of the hypothesis that the Bendigo veins have largely made room for themselves by mechanically displacing the inclosing country rock.

Although, as described by Stillwell, some of the inclusions of country rock have unquestionably been replaced by quartz, there is much evidence that the veins as a whole could not have been formed in this way. According to Dunn (page 16), "the opposite edges of the fissures in the country rock now filled by quartz are all quite angular and correspond in outline frequently on opposite sides of quartz veins"; and (page 27) "the frequent fitting of the country rock on opposite sides of the quartz veins shows how the quartz has gradually wedged the opposite sides apart." This observation was confirmed by Lindgren (page 164) who states that the "opposite sides of the jagged walls of the 'spurs' in many places would fit closely if joined again."

Stillwell notes (page 105) that "in many instances, however, in the larger reefs the included blocks of country rock are not replaced in the slightest degree"; and in his illustration of "preserved brecciation" (Plate V.), as well as in the photographs published by Dunn, the inclusions are angular and have sharply defined boundaries that separate them from the massive white vein quartz.

Specimens of ore from some of the gold-quartz veins of the Swauk district in central Washington contain similar inclusions of black shale, which microscopic examinaton shows have been largely replaced by silica; but the inclosing white quartz was evidently deposited in a very different manner.[2] The resemblance is increased by the fact that the silicified shale fragments contain segregated masses of graphitic material frequently arranged in broken lines.

Dr. Stillwell thinks that the laminated quartz, which "is very common and frequently carries the most gold," has originated through replacement of slate, and that this explains the peculiar structure of the ore. This theory is certainly not applicable to

[2] Taber, Stephen, "The Mechanics of Vein Formation." To appear in an early number of the *Bulletin, Am. Inst. Min. Eng.*

all laminated vein quartz; and there are certain facts concerning the laminated quartz of the Bendigo veins which seem to be irreconcilable with Dr. Stillwell's hypothesis.

Laminated quartz is found in many veins in the crystalline belt of the Southern Appalachians, and, while the gold production from these veins is to-day of comparatively little importance, the belief persists among the older miners that laminated quartz is a favorable indication of the presence of gold in payable quantities. Some of these veins possess a banded structure resulting from the alternation of narrow veinlets of quartz with thin parallel sheets of slate or schist. The veinlets are more or less lenticular in form, pinching out in places to be replaced by others a little to one side or farther along the strike, while frequently the layers of schist are wholly included within the quartz. The wall rock, which is commonly a quartz-sericite schist, shows little if any evidence of replacement by quartz, but often contains pyrite in single crystals and larger masses that partly replace and partly displace the older minerals. The same is true of the layers of schist occurring as inclusions within the vein except that from the thinner layers the quartz, in some cases, has been largely removed, leaving the sericite with a little chlorite and other accessory minerals. In a few rare instances garnets, cyanite and other metamorphic minerals have developed. The veins show every gradation from this banded structure to the typical laminated structure consisting of plates or layers of quartz separated by thin films of sericite.

Now while it is unquestionably true that replacement has usually been a factor in the formation of these veins, there is conclusive evidence that it has not been the most important factor. The veins frequently swell and pinch, and, in extreme cases, consist of a series of lenses disconnected or connected by almost imperceptible stringers. In the immediate vicinity of the veins the folia of the schists are curved to conform with the curvature of the lenses in such a way as to prove that the walls have been gradually pushed apart. Some of the large quartz lenses are subdivided by thin partitions of schist into smaller lenses and

layers.[3] In these instances it is clear that structural features, antedating the formation of the veins, have been displaced rather than replaced by the vein quartz.

The illustrations and detailed descriptions given in the reports of Dunn, Rickard and others indicate that the Bendigo veins have been formed by processes that are essentially similar to those which have resulted in the formation of other gold veins, such as those in the Southern Appalachians. The quotations given below are taken from Dunn's reports and require no comment. On page 23 he states: "Some legs consist of a series of lenticular bodies of quartz lying between the same bedding planes, and either connected by a thin quartz film or simply by a joint. Lying as they do between the bedding planes, the quartz forming the legs is generally well laminated." On page 24: "The whole thickness of the quartz in a leg is in some cases laminated (see Plate 15, B), . . . or it is laminated on the footwall, as in Plate 16, B, on the hanging wall (Plate 15, A), or it may consist entirely of white quartz, free from laminations (Plate 12, B)." Again on page 27 he says: "Laminated quartz abounds in all the mines, the quartz alternates with thin black slate films that have been stripped from the walls of the reef during the accretion of the quartz. In thin veins, or close to the walls, the quartz is most laminated. Such quartz is usually considered favorable for the occurrence of gold.

"The quartz along the walls in saddle reefs is generally laminated. As a rule, where quartz reefs cut across the beds there is no lamination, but an exception is met with in Collmann's fault where the walls of the fault were rubbed together so violently that films were formed along the walls. These were again detached as the quartz accumulated.

"Where the reefs are widest there the laminations are further apart, where narrowest, they are closest together. Sulphides appear more commonly in laminated stone, and perhaps gold also; it is certainly very frequent in such stone, the gold generally lies

[3] Taber, Stephen, "Geology of the Gold Best in the James River Basin, Virginia," *Va. Geol. Survey Bulletin* No. VII., pp. 165–168 and 224–229, 1913.

along the black films. . . . Instead of thin laminæ, in some cases thick substantial flakes of slate are included in the quartz."

The "spurs" that cut across the bedding planes in the slate show no evidence of laminations either parallel to the walls or parallel to the structural planes of the adjacent country rock, and yet the "spurs" in places branch off from the "leg reefs" and "saddle reefs." Why should replacement of slate be in any way limited to the veins that run parallel to the bedding planes?

The hypothesis that the Bendigo veins represent the filling of yawning cavities has been widely held in the past, but it is likewise open to serious objections. In several other districts veins have been found occurring in the crests and troughs of folded sedimentary rock strata, but open spaces, similar in form to "saddle reefs" have never been recorded in anticlinal folds, although folded rocks in all stages of dissection are exposed in many parts of the earth.

It does not seem possible that large cavities could have been formed and maintained under the conditions of deep burial and great pressure that existed during the intense folding to which the Lower Ordovician strata of the Bendigo gold-field were subjected. The beds are contorted into a series of folds, the anticlinal axes being only 300 to 1,300 feet apart, and superimposed on these major folds there are in places, especially in the slates, numerous complex minor crenulations along the lines of stratification. The great lateral pressure to which the beds have been subjected is also shown by the development of a slaty cleavage which frequently cuts across the bedding.

Where sharply bent the sandstone has been fractured along parallel or slightly radiating planes so as to give the rock a platy structure, and displacement has occurred along some of these fractures; but, under the same stresses, the more plastic slate has accommodated itself to the displacement by flowing. This is illustrated in Dunn's photographs especially in Plates 4, B and 11, A. Additional evidence of rock flowage is furnished by the way in which the slate beds are usually much thickened in the axes of the folds and correspondingly compressed in the limbs. Under

such conditions of rock flowage is it possible for large cavities to form and remain open?

While lateral pressure might conceivably, under favorable conditions, cause the formation of open cavities in the crests of anticlines, it would certainly tend to close all openings along the limbs of the folds, and yet, according to Dunn (page 23), "cases occur in which the quartz forms over an anticline down a syncline and over another anticline without any interruption," and "in some cases in this field the leg reefs are very persistent . . . and yet there is no development of a body of quartz or saddle reef where the plane they occur in is traced over the anticlinal axis." Lateral pressure can not account for the formation of a series of quartz lenses along the limbs of a fold between the same bedding planes.

It is inconceivable that veins as tortuous as those shown in some of Dunn's photographs (Plate 14, A and B) could ever have been formed in preëxisting open spaces, or that the numerous angular inclusions of country rock (see Plates 20, B and 22, A) could have reached their present position, if the veins were deposited in widely open cavities.

The phenomena discussed in the preceding paragraphs are all difficult or impossible of explanation under any theory of vein formation by replacement or by deposition in open spaces; but they all furnish evidence tending to confirm the hypothesis that the veins have largely made room for themselves by mechanically displacing the country rock. According to the latter concept the veins were deposited from ascending solutions, probably magmatic in origin, which were under great pressure and at high temperature. These solutions penetrated slowly along the lines of least resistance, such as fault fractures and planes of bedding or schistosity. Appreciable openings were filled, and, under favorable conditions, some of the country rock was replaced, but both of these processes were of minor importance. As the vein minerals separated from solution, pressure was developed tending to force apart the inclosing rock and thus make room for the growing veins. The mechanics of the process by which growing

crystals exert pressure has been discussed elsewhere,[4] and therefore need not be repeated here.

Where the solutions penetrated along closely spaced planes of bedding or schistosity, the thin layers and films of slate were more or less silicified, and at the same time they were gradually separated as the veins increased in size. The laminated quartz originated chiefly in this way. Solutions, entering the zones of complex fracturing, commonly present where beds of the more rigid sandstone had been sharply bent, deposited their minerals along the intersecting fractures, thus forming narrow veinlets which on growing gradually separated the rock fragments and formed the breccia ore. Mineral deposition probably began about favorable nuclei in the larger open spaces and where the least force was required in enlarging the openings. Circulation of solutions through the thin films that separated the growing crystals from one another and from foreign bodies was necessarily slow, and therefore under these conditions diffusion through the solution became an important factor in supplying additional material.

The forms assumed by the growing deposits were largely determined by the nature of the passage ways along with the solutions entered and by the forces resisting enlargement, the tendency always being to produce that shape which required the least expenditure of energy. This explains the growth of the largest deposits—the "saddle reefs"—in the crests of anticlines where the rocks were under least pressure, and also the swelling of "spurs" where they pass from sandstone into slates. Rickard states that "frequently a big 'blow' or irregular body of quartz is formed in the slate separating two beds of sandstone."[5]

The carbonaceous matter in the slates has probably acted as a precipitating agent for the sulphides and possibly for the gold. The sulphides seem to be more abundant near the walls and in vicinity of the slate inclusions. In places the pyrite is found

[4] Taber, Stephen, "Pressure Phenomena Accompanying the Growth of Crystals," *Proc. Nat. Acad. Sci.*, Vol. 3, pp. 297–302, 1917.

[5] Rickard, T. A., "The Bendigo Gold-Field (Second Paper): Ore Deposits Other Than Saddles," *Trans. Am. Inst. Min. Eng.*, Vol. XXI., p. 688 and Fig. 5, p. 693, 1892.

along the vein walls replacing both slate and vein quartz, thus furnishing additional evidence that the ore-bearing solutions, during the deposition of the vein minerals, were not confined to the widely open portion of partly filled fissures. Lindgren, in describing pyrite crystals found along the contact between the vein quartz and slate, states that they are in the form of cubes "of which one half is embedded in quartz and the other half in the black slate."[6]

STEPHEN TABER.

Sir: In your issue of May, 1918, Mr. Jacob W. Young comments on my paper on the "Halogen Salts of Silver at Wonder, Nevada," and suggests the hypothesis that the iodine and bromine had their origin as emanations from the interior of the earth rather than as solutions from the surface. This explanation of the origin of the silver haloids at Tonopah and Wonder was fully considered before either of my papers on this subject was written, but it was abandoned in favor of the theory of the derivation of the halogens from surface waters because of the controlling weight of field evidence to the contrary. A consideration of chemical facts and laws brought out no unexplainable objections to the theory that I presented, and only served to emphasize the fact that laboratory reactions very incompletely cover the field of possible chemical phenomena. Ostwald writes:

> What we call the chemical character of an element and employ for the estimation of its similarities and differences with respect to other elements, is made up of the sum total of the chemical processes, and physical properties known to us which this element and its compounds exhibit. It must, however, be at once admitted that our knowledge of these processes and properties is incomplete and highly onesided. It is incomplete even by reason of the limitation of all human knowledge; it is onesided in the highest degree because of all possible chemical processes, those occurring at medium and slightly higher temperatures are known with incomparably greater thoroughness than, for example, the processes occurring at much higher temperatures. . . . To employ a picture, we know only a certain, and, in part, somewhat arbitrarily cut section of the great organism of chemical facts while the rest of the body remains almost a secret to us.

[6] Lindgren, Waldemar, *op. cit.*, p. 164.

The questions Mr. Young raises are: (1) Why should the natural order of the precipitation of the halogen silver salts be inverted? (2) How did such an unusual concentration of bromine and iodine in proportion to silver come about? (3) Why should the solutions from which the silver was precipitated be assumed to be alkaline when the literature on the secondary enrichment of ore deposits emphasizes the acidic character of mine waters, especially those in the weathering section of the veins?

The answers to questions (1) and (2) can best be given together. In regard to question (1) I assume that by "natural order" Mr. Young means customary order, and refers to the order of precipitation of the halogen salts of silver customary under laboratory conditions. It must indeed be granted that the ore deposits under discussion were deposited in a natural order. In regard to question (2) Mr. Young appears to be under a misapprehension as to the relative amounts of the halogens in the solutions at Wonder required under my hypothesis. His inference is "that bromine is in amount equal to chlorine, and iodine is in big percentage." This is quite contrary to my conception of the case, which is that the circulating water contained a comparatively large proportion of chlorine, a very small proportion of bromine, and much less iodine. A consideration of the law of mass action, which I need not go fully into here, will suggest that although in the light of laboratory experience we might expect the salts to be precipitated in the order of iodide, bromide, chloride; a sufficiently great preponderance of chlorine over bromine, and bromine over iodine, would cause the order of precipitation to be precisely opposite. It is not necessary that all the chlorine be precipitated from the solution before the precipitation of bromine begins, but only that the concentration of chlorine be reduced to a point where mass action will favor the precipitation of bromine. In like manner, the precipitation of iodine may begin before either the chlorine or bromine are eliminated from solution, and consequently the quantities of the halogens found in the orebody have no recognizable relation to their relative proportions in the solution. To quote Ostwald again: "Not only the nature and, say, the temperature are the

determining factors for the occurrence of a chemical process, but also the *ratio of the substances present to the given volume or the concentration as well.*" The concentration of solutions worked with in the laboratories are so immensely greater, and the time of reaction so infinitesimally less than those involved in ore deposition, that the results of the laboratory cannot always be compared with those of nature, especially when facts and natural laws indicate the possibility of different results.

The occurrence of these salts in Nevada in the form of crystals, suggests a set of conditions of deposition very different from those of test tube reactions. To me it indicates concentrations so low as to be within the range of solubility of the halogen silver salts. Obviously we are here dealing with conditions about which we have no experimental evidence.

With regard to question (3), the difference should be emphasized between this class of ore deposits, which contain minute proportions of sulphide minerals, as compared with heavy deposits of base sulphides. In the Wonder vein descending alkaline surface waters would remain alkaline to a much greater depth than in a deposit heavy with sulphides. However, this would make no difference in regard to the formation of the silver haloids, as they are readily precipitated in acid solution. In this connection it should be remembered that there was practically no transportation of silver and the secondary minerals were found either on, or within a few inches of, the ore from which the silver was derived. My favorite conception of the process of formation of these minerals is that the alteration took place above the level of the ground water, as follows: Consider a piece of rich silver sulphide, cracked so that water can percolate through it, and lying in such a position that a slow seepage of oxidizing surface water passes through it. As a result of oxidation silver from the ore goes into solution as a sulphate, but it is immediately combined with one of the halogens and its precipitation begins. Its concentration may be so low that the silver salt will remain in solution long enough to be carried a short distance before the deposition is complete, and as a consequence we find crystals instead of amorphous precipitate. While I have pictured this as

taking place above water level, there is no serious objection to considering it as occurring in slowly moving solutions below water level.

The occurrence of the alkaline salts of chlorine, bromine and iodine at the locus of the orebody may be due either to wind blown salt-dust from nearby saline lakebeds, or from similar beds or salt lakes existing at the place before erosion occurred to its present extent.

Although I have here given first the theoretical considerations upholding my theory, their acceptance was, as I have already indicated, forced on me by the weight of field evidence. Where silver chloride is found, its invariable occurrence on the upper edges of silver-bearing veins, extending from the surface downward but limited to the depth of the oxidized zone, has never been questioned as being the result of action by surface water. I do not think it is necessary to review the arguments on this point. In the deposits that I have described the interrelations between the chloride, bromide, and iodide of silver were such that they must have had a common origin. In Tonopah they were found only in outcropping veins although there were numerous veins that did not have outcrops. At both Tonopah and Wonder there had been a large but undetermined amount of surface erosion, and it is not improbable that at Wonder a zone of silver chloride had been eroded away. Possibly this is the explanation of the absence of the chloride at Wonder.

In concluding this argument I would say it was inevitable that the theory proposed by Mr. Young should arise, and in my paper on the Tonopah deposits I anticipated it and gave reasons to the contrary; but, since the discussion has resulted in a more detailed exposition of the facts as well as of my theory, I thank Mr. Young for his interest in the subject.

Mr. Waldemar Lindgren's contribution telling of a description written fifty years ago of a similar deposit in Mexico is of interest. It is remarkable that there have been so few contributions to literature of descriptions of the "horn silvers," although they occur commonly enough.

J. A. BURGESS.

Sir: The paper by Victor Zeigler on "The Movements of Oil and Gas through Rocks," although brief, is the clearest and most complete review of the workable theories of oil migration. I agree with all its major features and conclusions, and will make only a few remarks on minor points.

Professor Ziegler calls attention to the possible effects of adhesion and adsorption of oil on various rock substances. Both adhesion and adsorption are phenomena that retard migration. They are interesting in their selective action on various parts of crude oil, as shown by filtration through fullers earth. From these experiments it is evident that different oils have different powers of adherence to a given substance; also that different substances hold an oil fraction with different powers of adsorption or adherence.

It appears that unsaturated hydrocarbons are absorbed on rock surfaces more strongly than saturated hydrocarbons. It appears that heavy oil fractions adhere more strongly than light fractions. It appears that clay surfaces are more efficient than quartz surfaces in producing these effects; also that they are increased by increase of area of surface through commination of the solid particles. It appears also that oils are made heavier when they are subjected to these processes of fractionation, if all the fractions are again brought together.

There is much mystery about adsorption and adhesion. We still lack a complete explanation of the oil-flotation process of concentrating metallic ores which exhibits related phenomena. No one knows just why the grease tables at Kimberley are successful in separating diamonds from pulverulent "blue-ground." The diamonds stick to the grease, and the other minerals slip over it and pass off the table.

It is generally thought that molecular forces are involved. I have crystals of calcite with inclusions of oil, in many very thin green layers that tend remarkably to follow certain buried faces of the growing crystal.

[1] Discussion of paper by Victor Ziegler, ECON. GEOL., Vol. XIII., No. 5, July, 1918, pp. 335–348.

A complete explanation of these phenomena seems to require further advance in the science of physics. Their main interest lies in their mystery.

I have a crystal of rock salt containing square inclusions of oil and round inclusions of gas. The difference probably indicates some mystery of crystallization.

The ability of oil to penetrate clay-shale is proven by its commercial occurrence in crevices in clay-shale. At Florence, Colo., and other places, these crevices do not connect with any sandstone or other porous stratum. The oil seems to have been formed in the shale. Regardless of its origin it must have migrated through clay-shale to reach the crevices.

I have hand specimens of basalt in which the steam-blebs contain zeolites with needles projecting to the center of the vesicles, showing that the cavities were once full of water. They are now full of the residue of oil. This oil must have penetrated the basalt for several inches and also a few millimeters of calcite and zeolite. Doubtless the oil made its way along invisible capillary passages between the rock particles and crystals.

CHESTER W. WASHBURNE.

SCIENTIFIC NOTES AND NEWS.[1]

MAJOR R. W. BROCK, of the University of British Columbia, has been appointed geological adviser to the British Army in Palestine. For the last two years he has been overseas on military duty.

WILLIAM FLEET ROBERTSON, Provincial Geologist of British Columbia, is on a visit to New York.

H. W. TURNER has recently made a geological reconnaissance of the Peace River oil field in northern Alberta.

PROFESSOR C. L. DAKE, of the Missouri School of Mines, has returned to his regular duties, after spending his years leave of absence as a petroleum geologist.

PROFESSOR JOSEPH BARRELL has returned to New Haven after spending considerable time in Bingham, Utah, in mining litigation work.

PROFESSOR E. K. SOPER, of the Oregon State School of Mines, has returned to Corvallis, Oregon, after three months of geological work in the Atlantic Coast and Great Lakes States.

H. A. COHEN is examining a mine in Plumas County, California.

JOHN C. GREENWAY, general manager for the Calumet & Arizona, has been promoted to lieutenant-colonel, and has been transferred, at his own request, from the Engineers to the Infantry of the A. E. F.

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

D. C. BARD, who has been engaged in geological work in Alaska, has returned to Seattle.

PROFESSOR WALDEMAR LINDGREN has gone to Bingham, Utah, in connection with mining litigation work.

COURTENAY DE KALB attended the Gold Conference of the Northwest Mining Association as a delegate from the American Gold Conference, held recently at Reno, Nevada.

J. MORGAN CLEMENTS sailed from San Francisco for Japan recently.

"POPULAR OIL GEOLOGY," by Victor Ziegler, reviewed by C. W. Tomlinson in the last number of ECONOMIC GEOLOGY, originally published by C .H. Merrifield, of Golden, Colorado, is now published by John Wiley and Sons.

HORACE V. WINCHELL was in San Francisco this week.

L. S. CATES, manager of the Ray mine, is serving on the Draft Appeal Board, at Phœnix, Arizona.

JAMES F. KEMP, Waldemar Lindgren, A. C. Lawson, Walter Wiley and Reno Sales are at Bingham, preparing evidence for the three apex cases that are impending.

GERALD SHERMAN, of Bisbee, Arizona, is visiting in Grass Valley, California.

ARTHUR NOTMAN, assistant superintendent for the Copper Queen Consolidated, has joined the Engineer Corps of the Army.

H. D. MCCASKEY, of the U. S. Geological Survey, was recently in San Francisco and Denver.

THE following letters were written from France by friends of the late John Duer Irving, and sent to the journal so that his scientific friends might know the nature and value of his work in France. The first is from Major Alfred H. Brooks, who for some time worked next door to Captain Irving; the second is from Fred Searles, well known as a mining geologist and at

present in the Engineers Corps, overseas; the third is from Major Evart Tracy who commanded the section to which Captain Irving was attached.

FRANCE:

My dear Dr. Bateman:

Irving's death has been a great loss to the service, and to me the loss of an old and very intimate friend. He worked in the military service as he has always in civil life, with the one end, the accomplishment of results, with no thought of self. Finally, worn out, he died, after accomplishing much and laying the foundation for a rational and scientific treatment of the subjects in his field—the teaching of methods of construction and designing shelters. Many a life will be saved, many a soldier live under sanitary conditions in the battle zone because of Irving's self sacrifice. In addition to his physical accomplishment, his high ideal of devotion to duty has been an inspiration to many a young officer. He finally made the supreme sacrifice to this ideal and gave his life to the cause. Those that mourn his loss have the comfort of knowing that his sacrifice has not been in vain and that because of Irving's accomplishments the end of the war is nearer.

I should be glad to be able to record for the benefit of you and other friends something of the details of Irving's service to the cause, but this is not permitted now. In better times to come I hope that this may be given out, to the end that it may be an inspiration—as it must be—to the students of science.

This and much more passed through my mind as I marched alongside the caisson bearing the body of our friend to his grave. The band playing a funeral march led a company of mining troops. This was especially appropriate, as it was the company that Irving had taught. The simple coffin was covered with the flag and buried under flowers. As a matter of record, I will give the pall-bearers.

Colonel Bond, Director of Engineers' School.
Colonel Wilby, in charge Engineer Intelligence Service.
Major Lampert, in charge of Bridge Designing.
Lieut. Col. Schulz, of Gas Service.
Major Tracy, of Camouflage Service.
Alfred H. Brooks.

It was followed by a large group of officers, led by Brig. Gen. Smith, including a dozen from the French Army. There were also a large number of privates, with a dozen from the French Army. There were also a large number of privates, with a dozen or more nurses and Y. M. C. A. workers and quite a few French civilians. A clergyman from the Y. M. C. A. read the service, but I can't recall his name for the present.

As we wound through the picturesque narrow streets of the old town, all in uniform stood at attention, and the civilians bared their heads.

The grave is on a sunny hill slope below the town in an American military cemetery adjacent to the old French burying ground. In accordance with custom, the three volleys from the company in line was followed by the bugle sounding taps. This was echoed by another bugler standing on the old city wall which commands the cemetery. These last rites were not performed simply as an official duty, but all who took part had a strong sense of personal loss, for Irving was admired and liked by all who knew him.

Sincerely Yours,
ALFRED H. BROOKS,
Gen. Headquarters,
Chief, Eng. Section.

FRANCE, July 21, 1918.

Dear Professor Kemp:

Being only slightly acquainted with Captain Irving's immediate relatives, I am taking the liberty of addressing to you this account of the circumstances attending his death, thinking that you would be glad to forward the information to those who are most interested.

The Captain has been engaged, since his connection with the Army Engineers' School, not only on instruction, but also on the design of standard dug-outs for the A. E. F., and on the preparation for publication in the New Engineer Field Notes of these designs, and the discussion of the standards and the proper methods for construction. This is most important work, and the Captain gave to it the utmost of his ability and untiring energies. He spared his subordinates, and never himself, and the urgency of the work was such that he was constantly spurred to topmost effort.

I have been with him a great deal and know how he worked and has worked ever since last December. His efforts were not unappreciated. He was on the eve of promotion and had long since gained some of the recognition that he deserved from G. H. Q. His loss is as serious to the Army Engineers as it is distressing to the many friends that he has already made in the Army.

He came to this post, July 10, after a fortnight's absence at headquarters, worn out with work and with a slight attack of the grip epidemic which has been very prevalent among us all. He delivered a lecture on the 11th, but became ill on the night of the 11th, and went to the hospital on the 12th. On the 15th, he was improved very much. He was sitting up, in good spirits, and none of us thought anything of the illness. Most of us had had the same dose. But that night he had a relapse, and on the 16th, developed a spot on his lungs. On the 17th he

was very ill with pneumonia. On the 20th, Lieutenant Leonareaux visited him, was alarmed at his condition, and succeeded in arranging a consultation for that night. I talked with the consulting doctor, Captain Guthrie (formerly Johns Hopkins), immediately after the consultation, midnight, the 19th, who stated that the condition was serious but not deseperate, and that Irving had a good chance. The following morning he was worse. They administered oxygen all day, and had a second consultation with an assistant of Colonel Thayer present. They still believed that there was a chance of recovery. The Captain had been delirious for forty-eight hours, and was unconscious all day the 20th. He died shortly before midnight.

His funeral will be held at 3 P.M. to-morrow (22d), with full military honors. His grave will be No. 58, Cemetery 13, A. E. F.

I can only express my own regrets and grief. I have come to know the Captain well in the past seven months, and my previous admiration for his ability and personality have deepened into the deepest respect and affection for him as a friend, superior officer, and man.

Sincerely,

FRED SEARLES, JR.,

A. P. O. 714, A. E. F., France.

. . . Before this reaches you, you may have heard of the death of Captain Irving, which occurred last night. I only wish to tell you what a loss it has been to the Army.

It is always sad to have anyone die here, otherwise than in action. In that event one always feels that it is a proper and glorious death.

Captain Irving died as gloriously as any man in the service has ever died. He gave all he had. The account of work he accomplished here in the design and adoption of his methods in mining and shelter dugouts, which are the only life savers when batteries are registered by the enemy, was beyond calculation.

He worked himself to death, and in the face of opposition, proved that he was right, time after time. We all remonstrated with him at his hours of work, but his devotion to duty as he conceived it, lowered his vitality and pneumonia, following a bad attack of the so-called Spanish grippe, cut him down.

When I tell you that since he was taken ill, the Personnel Department has been over the records of over fifty men trying to take his place, you can appreciate his value to the service.

If you can let any of his friends know what we, his close associates here feel about his loss, we will appreciate it.

No one has done more for the United States than he has.

Sincerely,

EVARTS TRACY.